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An Account of the TRANSIT OF VENUS, over the SUN's Disc, as observed near Cape-Henlopen, on Delaware Bay, June 3d, 1769.

By OWEN BIDDLE, JOEL BAILEY, and RICHARD THOMAS.

Drawn up, By OWEN BIDDLE.

A GREENABLE to the appointment of the *American Philosophical Society*, to observe the *Transit of Venus* at the Light-House, near Cape-Henlopen, I set out by water from Philadelphia, accompanied by Joel Bailey, and Richard Thomas, the latter of whom had offered to accompany us at his own expence, and proved very serviceable in the assistance he gave us.

ON the 26th of the 5th Month (May) we arrived at *Lewes-Town*, and immediately endeavoured to gain such information as might enable us to determine the best place for our Observations; and, on mature deliberation, we fixed on a place about one quarter of a mile S. W. of the town of *Lewes*, where a convenient house was to be had, in a retired situation, and having an open view of the sky.

WE found on our first landing on the beach, that neither the *Light-House*, nor any place near the sea-shore, would be suitable for our Observations; as it would be difficult to keep our instruments steady, or defend either the glasses of the Telescopes, or the eyes of the observers, from receiving injury by the sand which is wafted about by the wind.

HAVING chosen our place, we fixt up our instruments on the 27th of the month, and had some good corresponding altitudes of the Sun that day, by which we set our clock, and took some equal altitudes of fixt stars in the evening. The four following days continued cloudy, with frequent rains. But that we might not be idle in the mean time, and have it in our power to ascertain our latitude and longitude, in case we should be disappointed of celestial observations for that purpose; Joel Bailey and Richard Thomas, went to take the courses and distances from our place of Observation, to the provincial west line, which was run from Fenwick's Island to the *middle Point* of the peninsula; so that our *Observatory* might thereby be connected with Messrs. Mason and Dixon's meridian line.

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THE 1st of the 6th month (June) my associates returned from this service; and by their care and skill, I make no doubt, they performed it with the necessary precision.

WE had concluded that it would be a more expeditious way to take the courses, &c. from our Observatory to the west line, rather along the nearest public road than to run in one direct course through the woods; as by this last method, both the expence and delay of opening a vista, would have been necessary.

As the fixing the latitude and longitude of our Observatory must depend chiefly on this part of the work, I shall here insert the field notes, before I proceed to draw the conclusions from them. And I think it the more necessary to be particular in this request, that I may comply with the desire of the Astronomer Royal, express'd in his note to Dr. Franklin, as follows, viz.

Greenwich, December 11, 1769.

“ Mr. Maskelyne presents his compliments to Dr. Franklin, and shall be obliged to him, when he writes to Philadelphia, for enquiring of Mr. Owen Biddle, what is the bearing and what the absolute distance of Lewestown from the Stone on Fenwick’s Isle in English miles; or else what is the difference of latitude and departure in English miles? He may also, if he pleases, acquaint Mr. Biddle, that the latitude of the Middle Point between Fenwick’s Isle and Chesapeake Bay, as found by Messrs. Mason and Dixon, is $38^{\circ} . 27' . 34''$; and the length of a degree of latitude, as measured by them is 68,896 statute miles. Mr. Maskelyne would also recommend it to Dr. Smith, and the other Norriton-Observers, to settle the bearing and distance in English miles between Norriton and the southernmost point of the city of Philadelphia, or else the State House square; as this will still further confirm the situation of the Norriton-Observatory, by connecting it with Messrs. Mason and Dixon’s Meridian Line.

“ Mr. Maskelyne hopes, the Pennsylvania-Observers will be so kind as to send us their Observations of the TRANSIT OF MERCURY, which happened November 9th, if they were fortunate enough to see it; and any other Observations, they have made, which have not yet been sent here, tending to establish the difference of longitudes.”

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The COURSES and DISTANCES from the Observatory near Lewestown, to the Provincial West Line, between Fenwick's-Isle and Chesapeake-Bay, are as follows.

Courses.	Dist. in Perches.	Courses.	Dist. in Perches.	Courses.	Dist. in Perches.
o		o		o	
S. 43. 5 W.	495	S. 27. 15 W.	171	S. 10. o W.	56
S. 7. 30 E.	51	S. 43. o W.	23	S. 14. o E.	111
S. 45. 27 W.	446	S. 64. o W.	58	S. 23. o E.	54
S. 74. o W.	70	S. 50. o W.	26	S. 75. o E.	25
S. 68. 15 W.	44	S. 20. 40 W.	78	S. 64. o E.	65
S. 45. o W.	31	S. 30. o W.	41	S. 29. o E.	22
S. 35. 30 W.	52	S. 39. o E.	74	S. 13. 10 E.	81
S. 28. o W.	32	S. 44. o W.	52	S. 39. o E.	61
S. 82. 15 W.	56	S. 21. 30 W.	} 69,67	S. 9. o W.	24
N. 76. o W.	38	Acrofs In- dian Ri- ver.		S. 6. o E.	36
S. 42. 5 W.	102	S. 65. o W.	131	S. 25. o W.	84
S. 27. o W.	57	S. 64. o W.	78	S. 21. 30 E.	40
S. 64. o W.	33	S. 79. o W.	76	S. 40. o E.	57
S. 44. o W.	46	N. 80. o W.	52	S. 18. o E.	26
S. 2. o W.	45	S. 85. 30 W.	42	S. 12. o E.	78
S. 10. o W.	138	N. 76. o W.	63	S. 40. o W.	96
S. 30. 30 W.	216	S. 86. o W.	70	S. 10. 50 W.	86
S. 28. 40 W.	76	S. 65. o W.	66	S. 13. o E.	56
S. 25. o W.	104	S. 24. o W.	50	S. 28. o W.	70
South. - -	55	S. 18. 45 W.	73	S. 16. 10 E.	48
S. 8. o W.	96	S. 12. o E.	24	S. 6. o E.	26
S. 19. 5 W.	56	S. 6. o E.	48	S. 8. o W.	59
S. 26. o W.	80	S. 11. o E.	174	S. 22. o E.	46
S. 27. 30 W.	159	S. 6. o E.	73	S. 2. o W.	20
S. 8. o W.	270	S. 10. o W.	38	S. 42. o E.	42
S. 29. o W.	58	S. 11. o E.	112	S. 22. o E.	30
S. 11. 20 E.	164	S. 6. o E.	35	S. 48. o W.	46
S. 25. o E.	44	S. 19. o W.	16	S. 14. o E.	21
S. 28. 30 E.	58	S. 13. o W.	22	S. 18. o E.	48
S. 40. 30 E.	200	S. 29. o W.	46	S. 12. 30 E.	52
S. 30. 5 E.	45	S. 50. o E.	145	S. 42. o E.	49
S. 40. 5 E.	76	S. 61. o E.	48	S. 40. o E.	44
S. 58. o E.	44	S. 10. o E.	36	S. 14. o E.	110
S. 10. o W.	58	S. 21. 30 W.	110	South - -	31
S. 18. o E.	42	S. 10. o W.	56	S. 40. o E.	26
S. 12. o E.	84	S. 8. 30 E.	55	S. 14. o E.	22
S. 14. o E.	178	S. 27. 30 E.	34	S. 22. o W.	27
S. 10. o E.	44	S. 12. o E.	38		
S. 5. 30 E.	56	S. 10. o W.	30		
S. 21. o E.	60	S. 28. o W.	30		
S. 41. o W.	62	S. 38. o W.	75		
S. 21. o W.	40				
S. 5. o W.	18				

Here the Line from Fenwick's Isle to the Middle Point was intersected at 9 miles 86 perches, from the stone on Fenwick's Isle

The Needle, with which these Courses were taken, being compared with our Meridian Line, and also with the Prov. W. Line, was found to have 3°. 55'. Variation W. which was allowed for in reducing the Work, HENCE.

HENCE, from the above work, we get the Observatory near Lewestown,

West of the Stone on Fenwick's Isle 1895,5 perches, = 5 miles 295,5 perches.

East of the middle point, - - 9286,3 perches, = 29 miles 6,3 perches.

North of the middle point, - - 7007,5 perches, = 19° 4' 3".

The latitude of the middle point is, - - - 38° 27' 34"

The sum is the latitude of the Observatory, 38. 46. 38,3

Thus the latitude of the Observatory was fixed, and so would its longitude have been fixed by the above work also; if we had known either the longitude of the Middle Point, or of the Stone on Fenwick's Isle. But this not appearing from any part of the work of Messrs. Mason and Dixon, left among their public papers in this province, the AMERICAN PHILOSOPHICAL SOCIETY ordered us in the 5th Month, [May,] 1770, to take the Courses and Distances from New-Castle Court-House, to the Observatory in the State-House square, by which means the middle point, and consequently our Observatory at Lewes might be connected with the Philadelphia and Norriton Observatories, and so the longitude of the two latter being known; the longitude of the former would be known also. Our work is as follows.

COURSES. Begun at the Center of New-Castle Court-House, N. 39 . o W.	Distance in Perches. 3,52	Courses. N. 43. 30 E. 258 N. 45. 15 E. 168 N. 52. 30 E. 98 N. 60. 20 E. 232 N. 78. 20 E. 225 N. 62. 5 E. 132 N. 69. o E. 188 N. 71. o E. 135 N. 43. o E. 105 N. 58. o E. 112 N. 67. 45 E. 123 N. 49. o E. 105 N. 74. o E. 140 N. 64. o E. 76 N. 59. o E. 132 N. 73. 15 E. 148 N. 58. 30 E. 93 N. 26 30 W. 32 N. 56. 30 E. 136 N. 5. o E. 124 N. 35 25 E. 126 N. 61. o E. 280 N. 62. 15 E. 320	Perches. N. 69. o E. 189 N. 57. o E. 116 N. 37. 40 E. 438 N. 58. o E. 406 N. 47. 35 E. 120 N. 11. 40 E. 66 N. 55. 15 E. 42 S. 73. 20 E. 38 N. 83. 30 E. 37 S. 70. 40 E. 162 N. 73. 30 E. 45 N. 50. 30 E. 790 S. 88 15 E. 100 S. 71. 50 E. 189 S. 87. o E. 104 N. 55. o E. 432 S. 77. 40 E. 325,8 South. - - - 18
N. 32 . 40 E. 40			
N. 42. 00 E. 50			
N. 6. 50 E. 80			
N. 1. 50 W. 153			
N. 19. o E. 729			
N. 16. 30 E. 328			
N. 12. 30 E. 66			
N. 7. o E. 192			
N. 42. o E. 56			
N. 19. o W. 50,22			
North. - - - 89			
N. 2. o W. 181			
N. 7. o E. 56			
N. 35. o E. 20			
N. 59. 55 E. 944			
N. 41. 50 E. 87			
N. 51. 30 E. 276			
N. 49. o E. 48			

To the center of the Observatory in the State-House square.

N.B. The variation of the Needle, by which these Courses were taken was, 3° 15' West, which was allowed for in reducing the Work.

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Thus by the above work we get—		Perches
Newcastle Court-house West of Philadelphia Observatory	7011,5	
Middle Point of Peninsula West of New-Castle Court house	2212,2	
Their sum gives the middle point W. of Philad. Observatory	9223,7	
But (p. 92) the Middle Point is W. of the Lewes Observatory	9286,3	
Their difference gives the Lewes Observatory East of the Philadelphia Observatory	62,6	

This difference of sixty two perches does not give quite a second of time difference of longitude.

And as, both by the Philadelphia and Norriton observations, the longitude of the Philadelphia Observatory, West of Greenwich, is $5^h. 0'. 35''$
 The longitude of Lewes Observatory, West of Greenwich, is in time } $5. 0. 34$
 Or, in degrees and parts of the equator, the longitude of Lewes Observatory W. of Greenwich is } $75^{\circ}. 8'. 30''$
 And its latitude as above - - - - - $38. 46. 38,3$ North

For the advantage of navigation, we also took the courses and distances from our Observatory to the Provincial *Light House* near the Cape; and on reducing the work, we find the Light-House North of our Observatory $182,83$ perches, $=29'',8$; and East of the same 944 perches $=3'. 16'',8$.—Whence

The latitude of the Light-House, is $38^{\circ}. 47'. 8'',1$ North
 And its longitude, W. of Greenwich $75^{\circ}. 5'. 13'',2$

I now proceed to give an account of the remainder of our observations. The 2d of the Month we had several good corresponding altitudes of the Sun for setting our Time-piece.

THE 3d being the *Transit-Day*, was as fine in every respect for our Observation, as we could desire; the air calm, and not a cloud in view. We had a series of good corresponding altitudes of the Sun, taken in season, not to interrupt the Observation of the Transit.

ABOUT 12 o'clock we directed our Telescopes to the Sun, determined to keep it constantly in the field, till the contacts should be past; and in the mean time we set our boys (whom we had tutor'd for that purpose) to count the seconds by the clock, each boy counting one minute alternately, least they should be wearied, and not perform it with sufficient exactness. During the whole a person was standing by to overlook them, calling out each minute as it elapsed, and noting it down.

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WE

WE had agreed with each other to attend to our Telescopes one minute by turns, until about 7 or 8 minutes before the expected time, least by too steady attention, we should impair our sight, and disable ourselves from discerning the contact clearly. I had left my Telescope the minute preceding the contact, intending to apply myself steadily to it before the minute was fully elapsed; and not to quit it again until the contact occurred. When the 48th second was called, I applied myself to the Telescope, and by the time three seconds more were elapsed, I perceived on that part of the Sun's limb, where I had expected the contact to take place, a small impression, which proved to be the limb of Venus in contact with the Sun. All the limb of the Sun which appeared at that time in the field of the Telescope had a small undulatory motion, which I apprehended was occasioned by the ascent of dense vapours at this place (being near the sea). On the first appearance of Venus, it was like one of these small waves on the limb of the Sun, enlarged in so small a proportion, that I remained doubtful for several seconds, whether it was any thing besides. It continued making a deeper impression with that tremulous motion for about 10 seconds, when the tremor disappeared where Venus was in contact, and the indenture became truly circular with an even termination.

My absence from my Telescope, just before the contact occurred, deprived me of the opportunity of judging whether there was any appearance of an atmosphere preceeding the western limb of Venus as it came in contact; but when Venus had entered near one half her diameter on the disc of the Sun, my companion and I both saw a luminous crescent, which enlightened that part of Venus's circumference which was off the Sun, so that the whole of her circumference was visible; but it did not continue so, until the first internal contact took place.

At the time of the internal contact, agreeable to what was noted by some of the observers at the transit 1761; "the eastern limb of Venus seemed to be united to the limb of the Sun by a black protuberance or ligament, which was not broke
by

by the entrance of the thread of light," until 4 seconds after the regular circumference of Venus seemed to coincide with the Sun's.

For this observation I used a reflecting Telescope, magnifying about 150 times, which was in exceeding good order at the time, and defin'd the limb of the Sun, and spots on its disk, very nicely. I had applied a Polar Axis to it, and had altered the rack work, by which I could keep the same part of the limb in the field with ease.

My companion Joel Bailey was not so well provided with a Telescope. He had one of *Dollond's* double object lens refracting glasses of about four and an half feet length. This, with a bail and socket, was fixt to a post, which made it very convenient for observation. Thus furnished we found the contacts take place as follows.

JOEL BAILEY's external contact was lost by an accident, but seen by him after it had taken place, at 2^h. 14'. 30" Ap. T.
THE internal contact, by Do. 2. 32. 8

EXTERNAL contact, as seen by Owen }
Biddle, - - - - - } 2. 14. 8
THE internal contact by Do. 2. 32. 8

THESE Observations are reduced to appar. time. And it must be noted, that the time of the internal contact, as given by Owen Biddle, is 4 seconds before the thread of light had broke the dark ligament by which Venus's limb was-united to the limb of the Sun, that being the time he estimated the two limbs to be in contact. Also, that as the internal contact occur'd speedily after he went to his Telescope, he will not presume to assert that he has the time to a single second, yet he conceives he has given the exact time of that contact, as he is not sensible of any error therein.

THE foregoing being an exact diary of our Transactions, we submit the same to the Society, and hope for their approbation.
OWEN BIDDLE.

P. S. Since the foregoing was drawn up, I received from Dr. Smith the following note; which gives me pleasure to find so little difference between the result of Charles Mason and Jeremiah Dixon's measurement and our own.

Dear Sir,

" SINCE you finished your measurement from Newcastle Court-house to the Philadelphia Observatory in the State-house Square, the 58th vol. of Philos. Transac. has come to hand, containing the whole work of Messrs. Mason and Dixon in measuring a *degree of latitude*; and it is with great pleasure I find, that the longitude of the middle point of the peninsula (and consequently of your Observatory at Lewes) in respect to Philadelphia, will come out almost entirely the same from their work as from yours, altho' obtained by different * routes. *LONGITUDE of the Middle Point, and of the Lewes Observatory West of the Philadelphia Observatory, agreeable to the Lines of Messrs. Mason and Dixon.*

Observatory in the Forks of Brandiwine West of the South	}	miles. chains. lin.
point of the city of Philadelphia		31. 00. 00
Middle point of Peninsula East of Observatory in the Forks	}	2. 5. 49
The diff. gives the middle point of Penins. W. of S. point of Philad.		28. 74. 51
But S. point of Philad. is E. of Observatory in State house Square	}	0. 28. 75
The difference gives the <i>middle point</i> of Peninsula West of State-house Observatory		28. 45. 76
But by your work the middle point is W. of the Lewes Obs.	}	9286,3 = 29. 1. 57
The difference gives Lewes Observatory East of the State-house Observatory, from Mason and Dixon's Lines		0. 35. 81
But by your measure to Newcastle the Lewes Observatory was East of the State-house Observatory 62,6 perches	}	0. 15. 65
So that Mason and Dixon's lines give your Observatory more E. than your own work, only		0. 20. 16

Thus, by their work, we get your Observatory not quite 2", and by your own, not quite 1" East of the Observatory in the State-house Square. Wherefore 1" being taken as a mean, and applied to 5^h. 0'. 35" the longitude of the State-house Observatory West of Greenwich; the longitude of the Lewes Observatory may be well depended on as stated from your own work, to be in time West of Greenwich

5^h. 0'. 34"

N. B. As British mariners generally take their departure from the land's-end of England, and as by Mr. Bradley's observation of the late Transit of Venus the long. of the Lizard Point is now determined to be 5°. 15' W. of Greenwich if that be subtracted from 75°. 5'. 13", it will give---

The longitude of the Provincial Light-house near the Capes } West of Lizard Point } 69°. 50'. 13", 2

If you think the above can be of any use, you may add it to the end of your account. I think there is no mistake in bringing out the different results; but if I can find leisure I will re-examine the work before the sheet is struck off.

Philad. 23^d July, 1770.

I am, with great regard, yours, &c.

To Mr. OWEN BIDDLE.

WILLIAM SMITH.

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* The result by Mr. Biddle's book is got, by going from the State-House Observatory to New-Castle Court House, agreeable to his measurement; thence by the 12 m. radius and tangent line to the middle point. The result by Messrs. Mason and Dixon's work is got, by beginning at the fourth point of the city of Philadelphia, (or the place of their Observatory,) on the north side of Cedar-Street, between Front Street and Delaware; thence to their Observatory in the Forks of Brandiwine, which is 31 miles West, and 10, 5 South of the southernmost point of the city; thence by the other lines of latitude and departure, wherewith they connect the Observatory in the Forks of Brandiwine, with the middle point of the Peninsula. See their work in the vol. of Transactions, quoted above.